



RESTORATION ADVISORY BOARD

Little America
March 23, 2004



AGENDA



- ▮ Introduction
- ▮ Approval of Minutes November 18, 2003
- ▮ Discussion/Questions on Environmental Restoration Project Status
- ▮ Community Co-Chair Election
- ▮ Draft Revised Proposed RAB Rule
- ▮ Potential Remedies for Zone D Groundwater
- ▮ Discussion/Question & Answer Session
- ▮ Meeting Logistics
 - ▮ Recommendation: May 18, 2004 at Little America
- ▮ Adjournment



APPROVAL OF MINUTES

November 18, 2003

Meeting



Discussion/Questions on Environmental Restoration Project Status



NEW CO-CHAIR ELECTION



Draft Revised Proposed RAB Rule



ZONE D GROUNDWATER FEASIBILITY STUDY

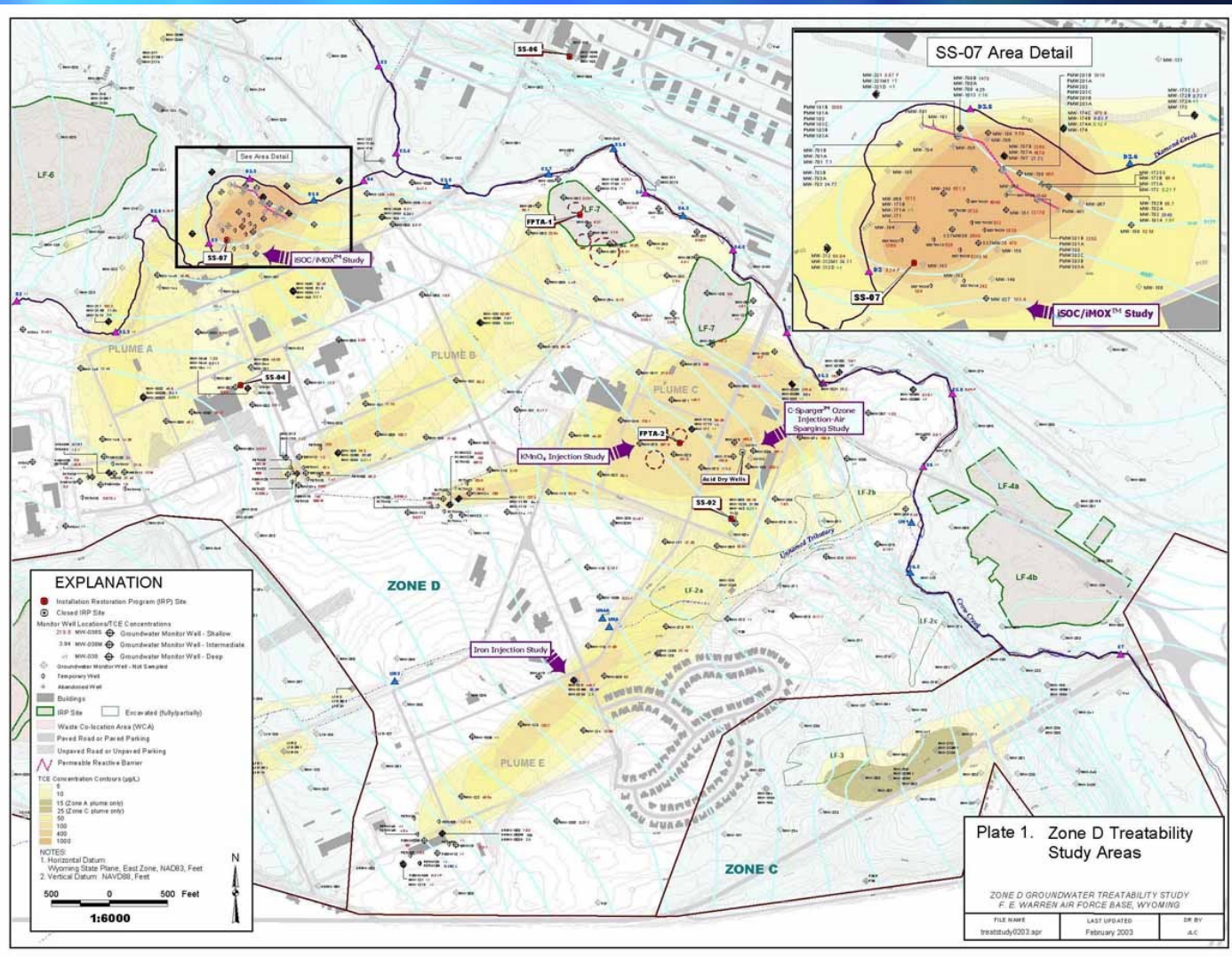


OVERVIEW



- ▢ Site Background:
 - RAOs
 - Cleanup Strategies
 - Modeling
- ▢ Alternatives:
 - General Approach
 - By Plume

SITE LOCATION MAP





REMEDIAL ACTION OBJECTIVES



- ▢ Restoration of contaminated groundwater to beneficial use
 - TCE and degradation products to respective MCLs
- ▢ Prevent concentrations of TCE and degradation products from exceeding the applicable state surface water standards (Chapter 1 of the WWQRR)
- ▢ Prevent VOC vapors associated with groundwater plumes from accumulating to unacceptable levels in indoor air in proposed future buildings



CLEANUP STRATEGIES



- ▢ Localized Reduction of Contaminant Mass
 - Focus on residual areas to shorten natural attenuation timeframes
- ▢ Natural attenuation
- ▢ Creek protection and surface water aeration
- ▢ Institutional control to limit TCE vapors in future buildings

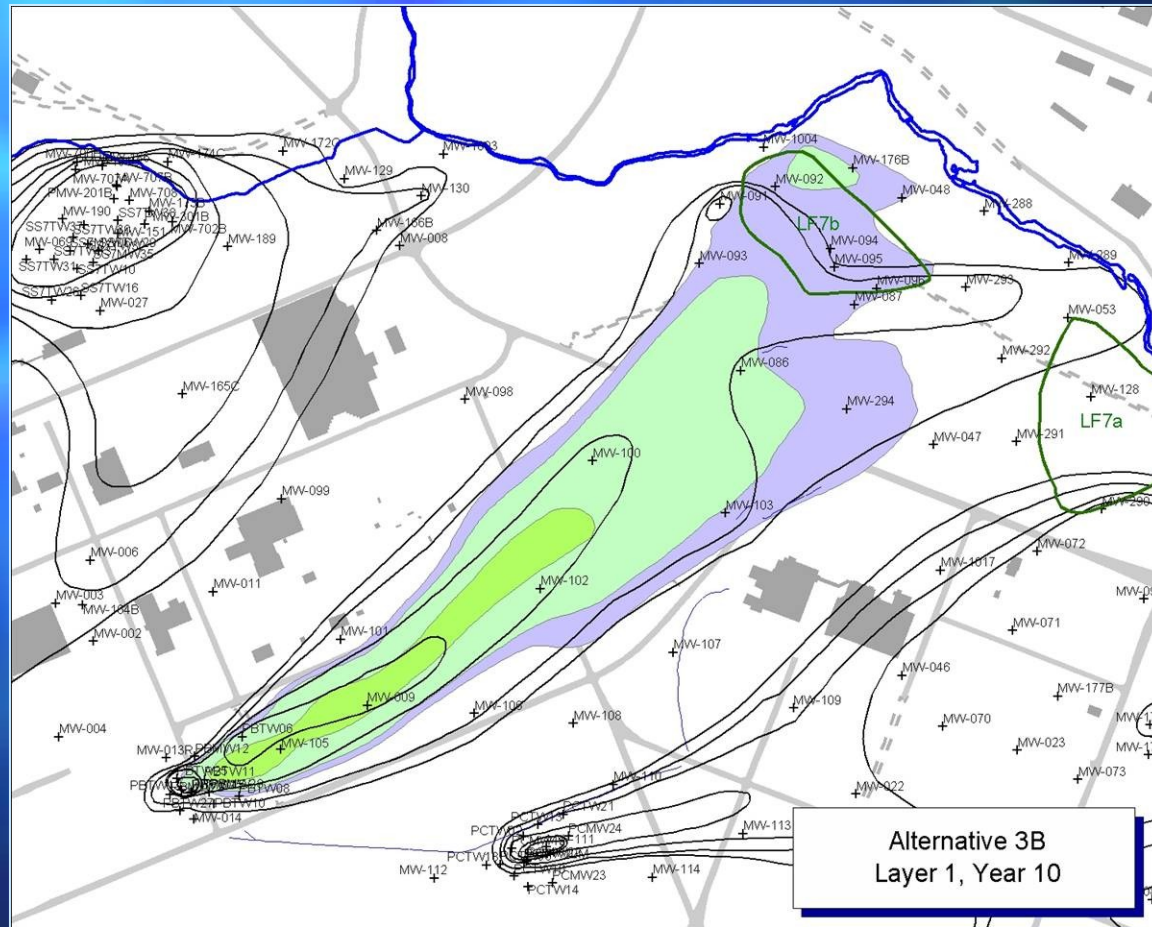


GW MODELING

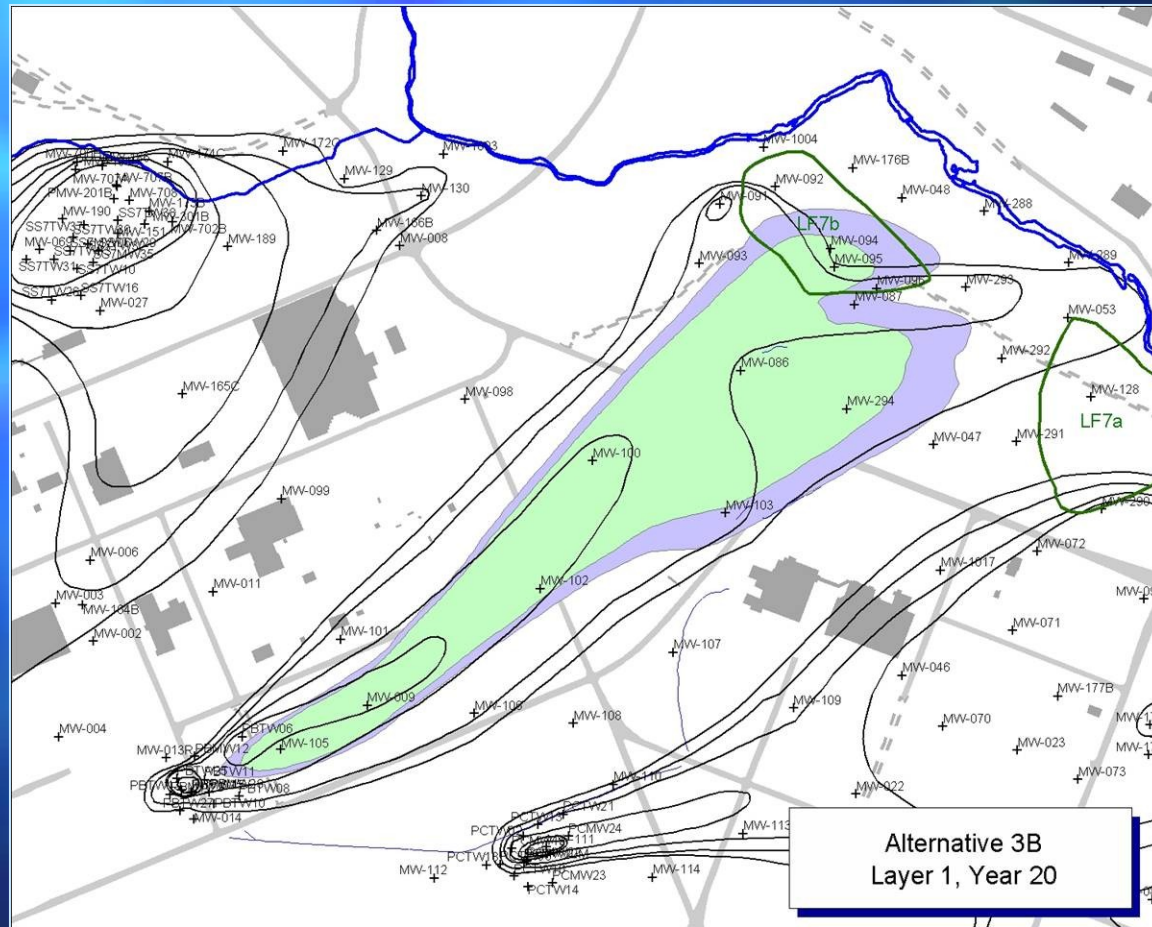


- ▣ Model(s): ModFlow, MT3D
- ▣ Calibration
 - Flow model: Potentiometric surface, stream discharge, vertical gradients & compared to aquifer tests
 - Transport: Historic plume migration
- ▣ Alternative Simulations/Time Series
 - Initial condition
 - Year 10 to near end of MNA period
 - Plume B shallow zone is used in the following example

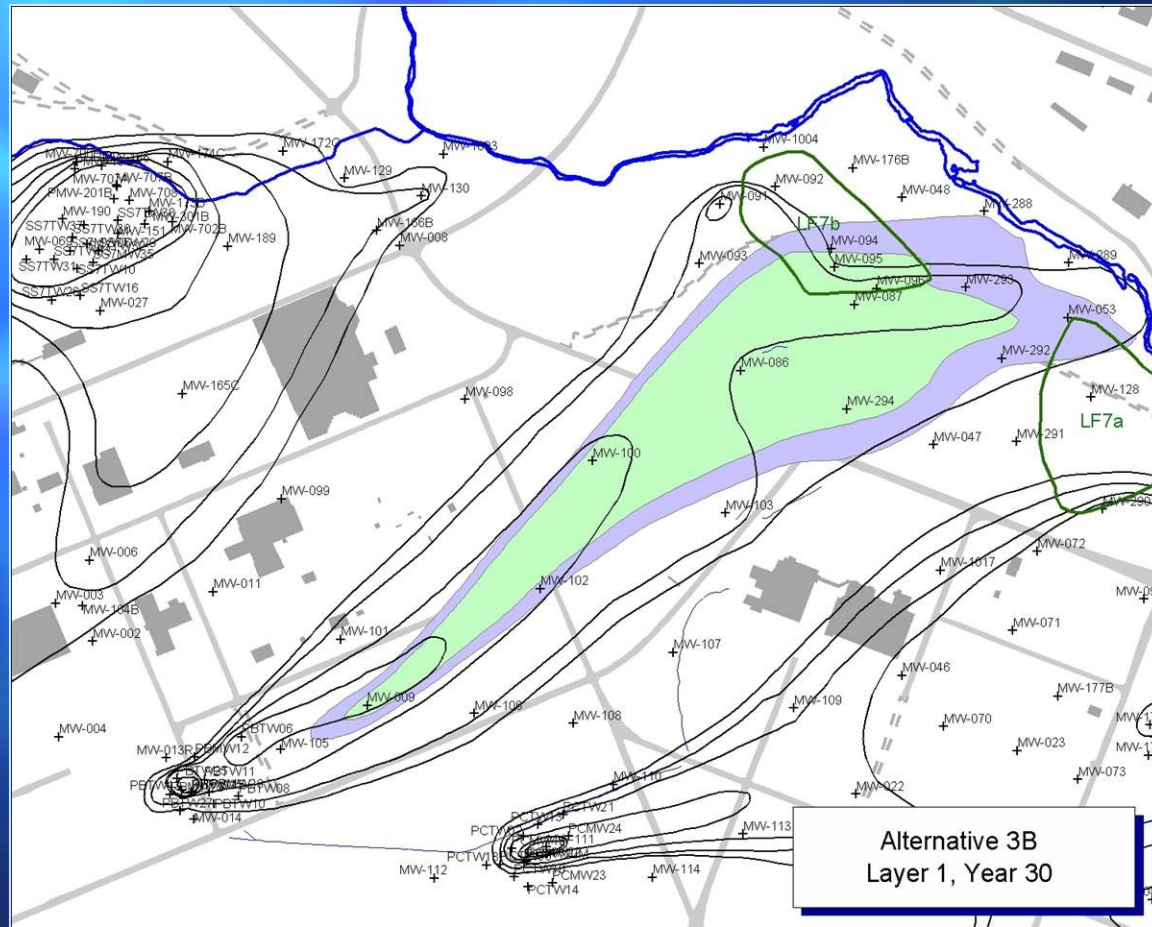
PLUME B - YEAR 10



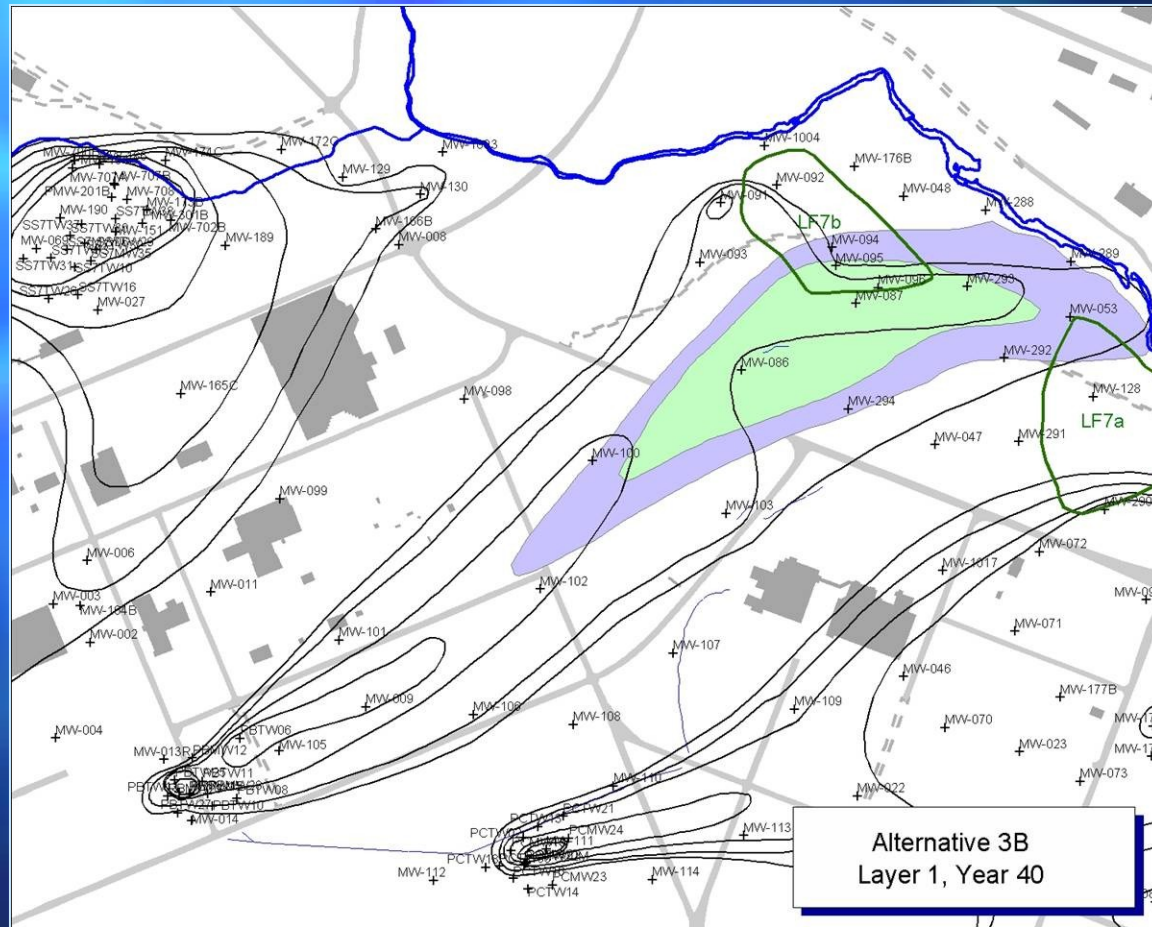
PLUME B - YEAR 20



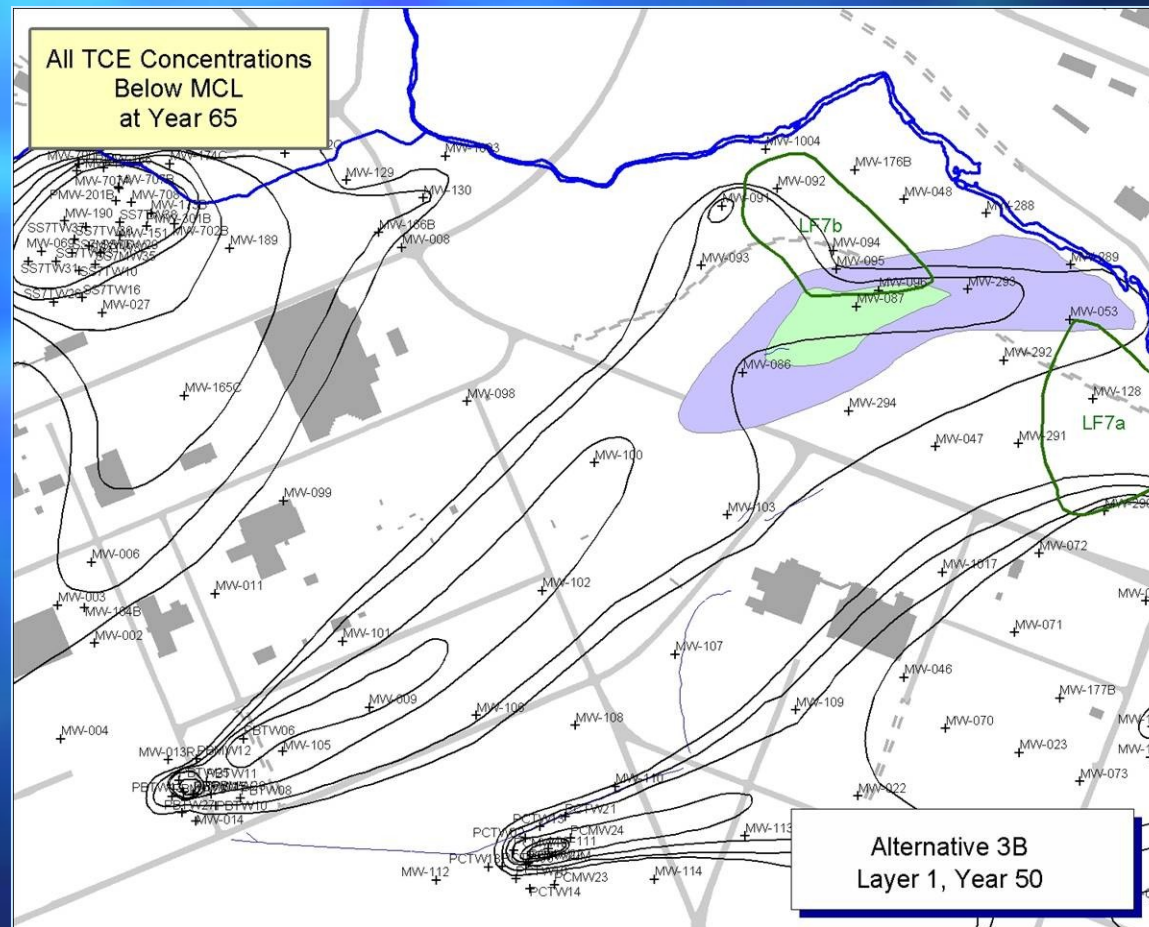
PLUME B - YEAR 30



PLUME B - YEAR 40



PLUME B - YEAR 50





GENERAL APPROACH TO ALTERNATIVES



- 1 - No Action
 - Required by NCP
- 2 - Institutional Controls
- 3 - Monitored Natural Attenuation (MNA)
 - As applicable
- 4 - Groundwater Extraction, Ex-situ Treatment (P&T)
 - EPA Presumptive Remedy
 - As applicable (with MNA component)
- 5/6 - Hybrid Alternative(s)
 - Previous experience at similar sites
 - Site constraints
 - Time-frame

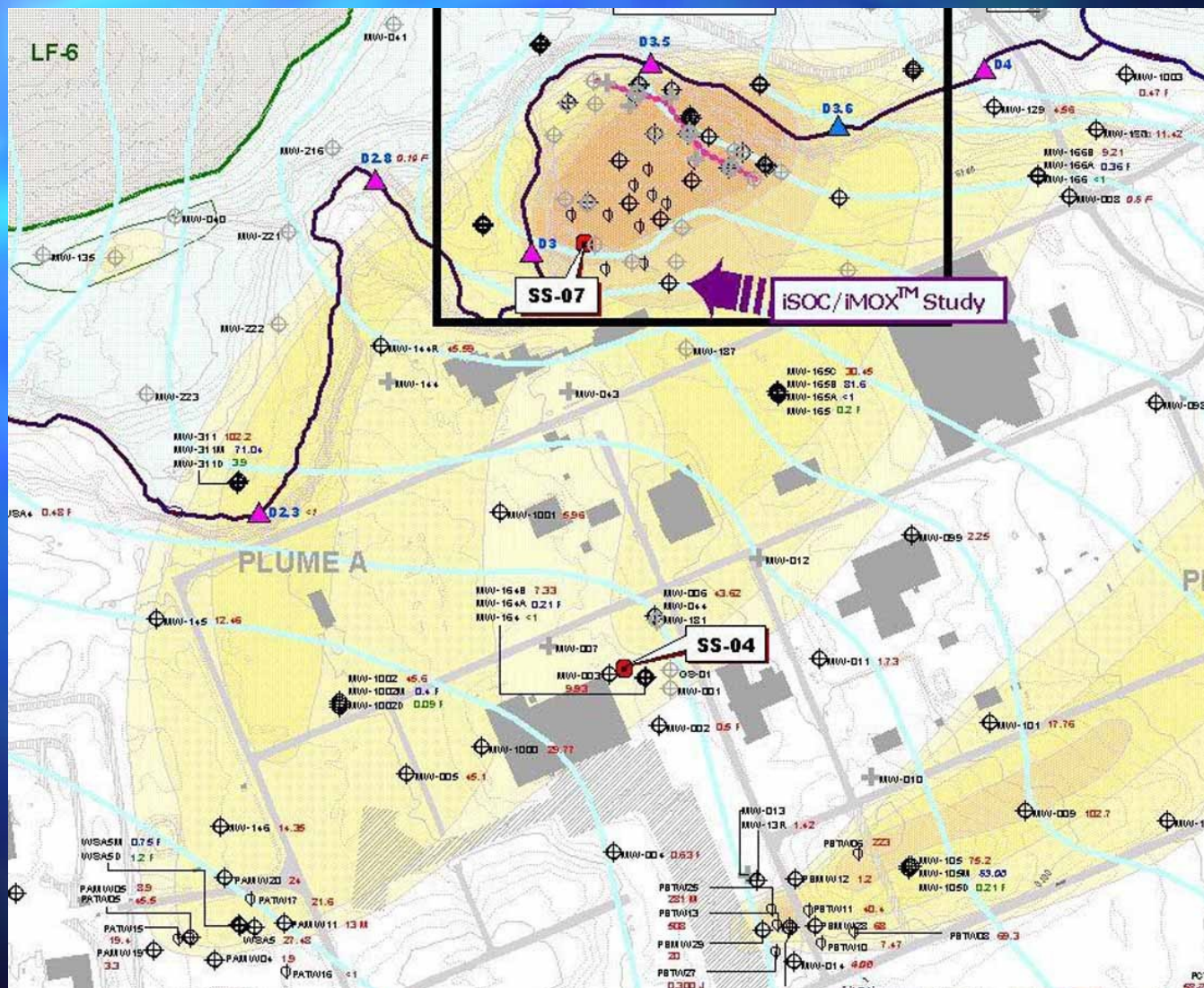


INSTITUTIONAL CONTROLS



- ▮ Applicable to all Zone D plumes
- ▮ Drinking water at FEW supplied by municipality
- ▮ Groundwater identified as 'potential' source
- ▮ Existing language in General Plan
- ▮ Primary addition to General Plan for all plumes relates to future buildings and potential for vapor migration
 - Sub-slab depressurization systems in risk areas

PLUME A SITE MAP





PLUME A (Excluding SS7)



- ▢ Plume area = 91 acres
- ▢ $\text{TCE}_{\text{MAX}} = 102.2 \mu\text{g/L}$; $\text{TCE}_{\text{MASS}} = 37 \text{ kg}$
- ▢ No evidence of continuing source
- ▢ Plume stable, edges shrinking
 - ▽ ↓ TCE over last 10-15 years
 - Biodegradation evident (presence of cis-1,2-DCE)
 - Half-life_{AVG} for TCE ~ 6-8 years
- ▢ Plume intercepts & flows under Diamond Creek
 - Mass loading to Diamond Creek ~ 1.1 gm/day TCE
 - Empirical SW data < 1 $\mu\text{g/L}$ TCE
 - Dilution, volatilization
- ▢ Sensitive species habitat along creek
 - Colorado Butterfly Plant & Preble's Meadow Jumping Mouse



PLUME A ALTERNATIVES



Shallow Zone Alternatives:

- ▣ 1A - No Action
- ▣ 2A - Institutional Controls
- ▣ 3A - MNA
- ▣ 4A - P&T & MNA
- ▣ 5A - Localized Bioaugmentation & MNA

Intermediate Zone Options:

- ▣ 1A-INT - No Action
- ▣ 2A-INT - Institutional Controls
- ▣ 3A-INT - MNA
- ▣ 4A-INT - Localized ChemOx & MNA



ALTERNATIVE 3A



MNA

Monitoring:

- 12 wells (S) + 4 wells (I) after shallow zone attenuates
- Yr 1: Quarterly
- Yrs 2-5: Annually
- Once every 5 years thereafter

Time to achieve RAOs (TCE < 5 µg/L)

- Shallow: 50 years
- Intermediate: 120 years



ALTERNATIVE 4A



P&T & MNA

□ P&T:

- Presumptive Remedy
- 103 2-Phase Extraction Wells (40 gpm total)

□ MNA:

- 12 shallow wells + 4 intermediate wells

□ Time to achieve RAOs (TCE < 5 µg/L)

- Shallow: 20 years
- Intermediate: 120 years



ALTERNATIVE 5A



Localized Bioaugmentation & MNA

▢ Bioaugmentation:

- Area of TCE > 100 $\mu\text{g/L}$ (18.5 acres based on modeling)
- 1076 injection wells, single injection, 2 lbs/inj.

▢ MNA :

- 12 shallow wells + 4 intermediate wells

▢ Time to achieve RAOs (TCE < 5 $\mu\text{g/L}$)

- Shallow: 35 years
- Intermediate: 120 years

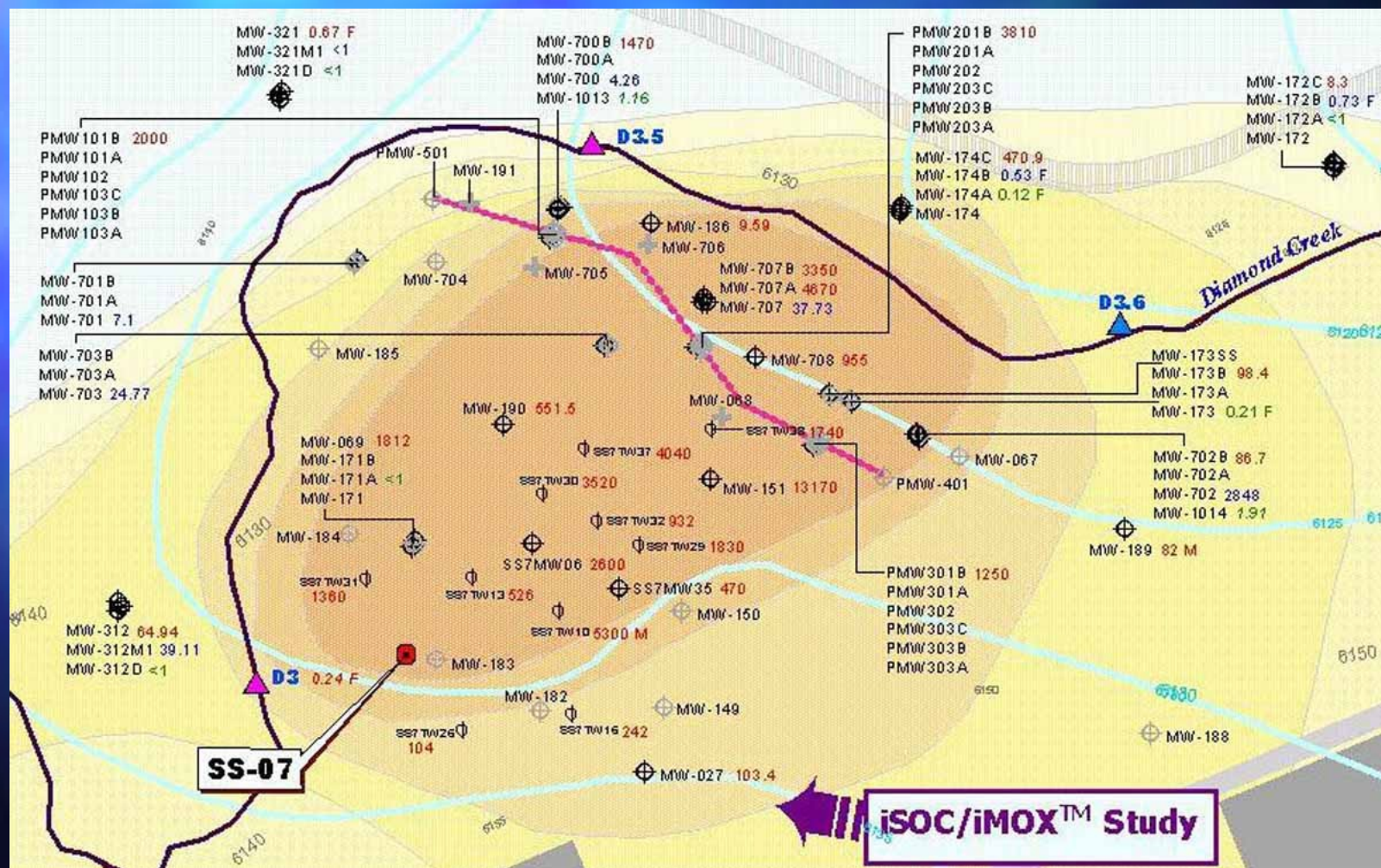


PLUME A SUMMARY



| Alternative | Description | Timeframe to Achieve Groundwater RAOs (Years) | Capital Costs | Total Operations and Maintenance (O&M) Cost | Present Value Cost |
|-------------|---|---|---------------|---|---------------------------|
| 1A | No Further Action | 50 | -- | -- | -- |
| 2A | Institutional Controls | 50 | \$18,484 | \$119,350 | \$61,181 |
| 3A | MNA | 50 | \$0 | \$2,616,440 | \$1,133,542 |
| 4A | Groundwater Extraction and <i>Ex situ</i> Treatment | 20 | \$2,038,778 | \$9,608,942 | \$7,379,022 |
| 5A | Localized Bioaugmentation and MNA | 35 | \$11,756,353 | \$2,324,076 | \$12,284,520 |
| 1A-INT | No Further Action | 120 | -- | -- | \$1,200 |
| 2A-INT | Institutional Controls | 120 | \$0 | \$119,350 | \$4,000 (Years 51-120) |
| 3A-INT | MNA | 120 | \$0 | \$4,452,780 | \$734,761 |
| 4A-INT | Localized ChemOx and MNA | 110 | \$1,906,675 | \$3,623,598 | \$2,479,258 |

SS7 SITE MAP





SPILL SITE 7



- ▢ Plume area = 11 acres
- ▢ $TCE_{MAX} = 13,170 \mu\text{g/L}$; $TCE_{MASS} = 171\text{kg}$
 - $TCE \sim 21,000 \mu\text{g/L}$ in 1998
- ▢ IRA successfully implemented in 1999 using ZVI PRB
 - RAO's: reduce loading to creek and clean shallow GW
 - Integrate IRA into Final Remedy
 - PRB life-span 30-50 years
- ▢ Localized continuing sources (residual/adsorbed phase)
- ▢ Plume intercepts & flows under Diamond Creek
 - Mass loading to Diamond Creek estimated at 6.7 gm/day
 - Empirical SW data $\sim 20 \mu\text{g/L}$ at D3.6
- ▢ Local groundwater divide - flow E-NE and NW
- ▢ Sensitive species habitat (CO Butterfly Plant & Preble's Mouse)



SPILL SITE 7 ALTERNATIVES



Shallow Zone Alternatives:

- ▯ 1S - No Action
- ▯ 2S - Institutional Controls
- ▯ 3S - Existing PRB & MNA
- ▯ 4S - Existing PRB, West PRB, & MNA
- ▯ 5S - Existing PRB, Bioaugmentation, & MNA
- ▯ 6S - ERH, ChemOx, & MNA (discount PRB)

Intermediate Zone Options:

- ▯ 1S-INT - No Action
- ▯ 2S-INT - Institutional Controls
- ▯ 3S-INT - MNA
- ▯ 4S-INT - Localized ChemOx & MNA



ALTERNATIVE 3S



Existing PRB & MNA

Existing PRB

- Life-span ~ 30-50 years
- Assumes replacement PRB after 30 years

MNA :

- 12 shallow wells + 4 intermediate wells
- Additional wells & surface water locations not costed

Time to achieve RAOs ($\text{TCE} < 5 \mu\text{g/L}$)

- Shallow: 100 years
- Intermediate: 290 years



ALTERNATIVE 4S



Existing PRB, West PRB, & MNA

▢ West PRB:

- 500 ft long x 30 ft deep x 2 ft thick

▢ MNA:

- 12 shallow wells + 4 intermediate wells
- additional wells & surface water locations not costed

▢ Time to achieve RAOs ($\text{TCE} < 5 \mu\text{g/L}$)

- Shallow: 100 years
- Intermediate: 290 years



ALTERNATIVE 5S



Existing PRB, Bioaugmentation, & MNA

▢ Bioaugmentation:

- 459 injection wells, single injection, 2 lbs/inj.

▢ MNA:

- 12 shallow wells + 4 intermediate wells
- additional wells & surface water locations not costed

▢ Time to achieve RAOs ($\text{TCE} < 5 \mu\text{g/L}$)

- Shallow: 35 years
- Intermediate: 290 years



ALTERNATIVE 6S



ERH, ChemOx, & MNA (discount existing PRB)

ERH/SVE:

- Applied to areas with TCE > 5000 µg/L
- 58 electrodes, 58 extraction wells

ChemOx (Fenton's Reagent):

- Applied to areas with TCE > 1000 µg/L
- ~ 2 acres (20 ft grid)

ChemOx (KMnO₄):

- Applied to areas with TCE > 80 µg/L
- ~ 2 acres, 430 total ChemOx injection points (20 ft grid)

MNA:

- 12 shallow wells + 4 intermediate wells

Time to achieve RAOs (TCE < 5 µg/L)

- Shallow: 85 years
- Intermediate: 290 years



SPILL SITE 7 SUMMARY



| Alternative | Description | Timeframe to Achieve Groundwater RAOs (Years) | Capital Costs | Total O&M Cost | Present Value Cost |
|-------------|--|---|---------------|----------------|--------------------------|
| 1S | No Further Action | 100 | -- | -- | -- |
| 2S | Institutional Controls | 100 | \$18,484 | \$238,700 | \$64,981 |
| 3S | Existing PRB & MNA | 100 | \$6,085,270 | \$4,565,970 | \$1,918,270 |
| 4S | Extend Existing PRB, West PRB, & MNA | 100 | \$15,332,154 | \$4,565,970 | \$4,617,360 |
| 5S | Existing PRB, Bioaugmentation, & MNA | 35 | \$2,478,272 | \$2,284,053 | \$3,467,083 |
| 6S | ERH, Chemical Oxidation, & MNA (discount Existing PRB) | 85 | \$7,942,981 | \$4,045,636 | \$8,766,749 |
| 1S-INT | No Further Action | 290 | -- | -- | \$1,200 |
| 2S-INT | Institutional Controls | 290 | \$0 | \$167,090 | \$245 (Years 101-290) |
| 3S-INT | MNA | 290 | \$0 | \$11,447,165 | \$741,263 |
| 4S-INT | Localized ChemOx & MNA | 175 | \$592,380 | \$5,244,772 | \$1,219,615 |



Surface Water Treatment Options



Groundwater at SS7 discharges to Diamond Creek
(Class 3B; no TCE standard)

Discharge of Diamond Creek to Crow Creek (Class 2AB; TCE standard=2.7ug/L) can potentially lead to TCE exceedances in Crow Creek.

- ▮ **Channel Drop Structures - \$35 to \$60K**
- ▮ Instream Fountain - \$45 to \$80K
- ▮ Indoor Water Cascade - \$55 to \$100K
- ▮ Instream Bubbler - \$65 to \$90K

The map displays the Fernald site with various monitoring wells and study areas. Key features include:

- ISOC/IMOX™ Study:** Indicated by a purple arrow pointing left towards the left side of the map.
- FPTA-1:** A study area outlined in green, containing several monitoring wells.
- LF-7:** A specific area within FPTA-1, outlined in red dashed lines.
- FPTA-2:** Another study area outlined in green, located towards the bottom right.
- KMnO₄ Injection Study:** Indicated by a purple arrow pointing right towards the bottom right of the map.
- Acid Dry Wells:** A cluster of wells in the bottom right corner.
- SS-02:** A label in the bottom right corner.
- PLUME B and PLUME C:** Large areas of the map shaded in yellow, representing contaminant plumes.
- Monitoring Wells:** Numerous wells are marked with codes (e.g., MW-100, MW-101, MW-102, MW-103, MW-104, MW-105, MW-106, MW-107, MW-108, MW-109, MW-110, MW-111, MW-112, MW-113, MW-114, MW-115, MW-116, MW-117, MW-118, MW-119, MW-120, MW-121, MW-122, MW-123, MW-124, MW-125, MW-126, MW-127, MW-128, MW-129, MW-130, MW-131, MW-132, MW-133, MW-134, MW-135, MW-136, MW-137, MW-138, MW-139, MW-140, MW-141, MW-142, MW-143, MW-144, MW-145, MW-146, MW-147, MW-148, MW-149, MW-150, MW-151, MW-152, MW-153, MW-154, MW-155, MW-156, MW-157, MW-158, MW-159, MW-160, MW-161, MW-162, MW-163, MW-164, MW-165, MW-166, MW-167, MW-168, MW-169, MW-170, MW-171, MW-172, MW-173, MW-174, MW-175, MW-176, MW-177, MW-178, MW-179, MW-180, MW-181, MW-182, MW-183, MW-184, MW-185, MW-186, MW-187, MW-188, MW-189, MW-190, MW-191, MW-192, MW-193, MW-194, MW-195, MW-196, MW-197, MW-198, MW-199, MW-200, MW-201, MW-202, MW-203, MW-204, MW-205, MW-206, MW-207, MW-208, MW-209, MW-210, MW-211, MW-212, MW-213, MW-214, MW-215, MW-216, MW-217, MW-218, MW-219, MW-220, MW-221, MW-222, MW-223, MW-224, MW-225, MW-226, MW-227, MW-228, MW-229, MW-230, MW-231, MW-232, MW-233, MW-234, MW-235, MW-236, MW-237, MW-238, MW-239, MW-240, MW-241, MW-242, MW-243, MW-244, MW-245, MW-246, MW-247, MW-248, MW-249, MW-250, MW-251, MW-252, MW-253, MW-254, MW-255, MW-256, MW-257, MW-258, MW-259, MW-260, MW-261, MW-262, MW-263, MW-264, MW-265, MW-266, MW-267, MW-268, MW-269, MW-270, MW-271, MW-272, MW-273, MW-274, MW-275, MW-276, MW-277, MW-278, MW-279, MW-280, MW-281, MW-282, MW-283, MW-284, MW-285, MW-286, MW-287, MW-288, MW-289, MW-290, MW-291, MW-292, MW-293, MW-294, MW-295, MW-296, MW-297, MW-298, MW-299, MW-300, MW-301, MW-302, MW-303, MW-304, MW-305, MW-306, MW-307, MW-308, MW-309, MW-310, MW-311, MW-312, MW-313, MW-314, MW-315, MW-316, MW-317, MW-318, MW-319, MW-320, MW-321, MW-322, MW-323, MW-324, MW-325, MW-326, MW-327, MW-328, MW-329, MW-330, MW-331, MW-332, MW-333, MW-334, MW-335, MW-336, MW-337, MW-338, MW-339, MW-340, MW-341, MW-342, MW-343, MW-344, MW-345, MW-346, MW-347, MW-348, MW-349, MW-350, MW-351, MW-352, MW-353, MW-354, MW-355, MW-356, MW-357, MW-358, MW-359, MW-360, MW-361, MW-362, MW-363, MW-364, MW-365, MW-366, MW-367, MW-368, MW-369, MW-370, MW-371, MW-372, MW-373, MW-374, MW-375, MW-376, MW-377, MW-378, MW-379, MW-380, MW-381, MW-382, MW-383, MW-384, MW-385, MW-386, MW-387, MW-388, MW-389, MW-390, MW-391, MW-392, MW-393, MW-394, MW-395, MW-396, MW-397, MW-398, MW-399, MW-400, MW-401, MW-402, MW-403, MW-404, MW-405, MW-406, MW-407, MW-408, MW-409, MW-410, MW-411, MW-412, MW-413, MW-414, MW-415, MW-416, MW-417, MW-418, MW-419, MW-420, MW-421, MW-422, MW-423, MW-424, MW-425, MW-426, MW-427, MW-428, MW-429, MW-430, MW-431, MW-432, MW-433, MW-434, MW-435, MW-436, MW-437, MW-438, MW-439, MW-440, MW-441, MW-442, MW-443, MW-444, MW-445, MW-446, MW-447, MW-448, MW-449, MW-450, MW-451, MW-452, MW-453, MW-454, MW-455, MW-456, MW-457, MW-458, MW-459, MW-460, MW-461, MW-462, MW-463, MW-464, MW-465, MW-466, MW-467, MW-468, MW-469, MW-470, MW-471, MW-472, MW-473, MW-474, MW-475, MW-476, MW-477, MW-478, MW-479, MW-480, MW-481, MW-482, MW-483, MW-484, MW-485, MW-486, MW-487, MW-488, MW-489, MW-490, MW-491, MW-492, MW-493, MW-494, MW-495, MW-496, MW-497, MW-498, MW-499, MW-500, MW-501, MW-502, MW-503, MW-504, MW-505, MW-506, MW-507, MW-508, MW-509, MW-510, MW-511, MW-512, MW-513, MW-514, MW-515, MW-516, MW-517, MW-518, MW-519, MW-520, MW-521, MW-522, MW-523, MW-524, MW-525, MW-526, MW-527, MW-528, MW-529, MW-530, MW-531, MW-532, MW-533, MW-534, MW-535, MW-536, MW-537, MW-538, MW-539, MW-540, MW-541, MW-542, MW-543, MW-544, MW-545, MW-546, MW-547, MW-548, MW-549, MW-550, MW-551, MW-552, MW-553, MW-554, MW-555, MW-556, MW-557, MW-558, MW-559, MW-560, MW-561, MW-562, MW-563, MW-564, MW-565, MW-566, MW-567, MW-568, MW-569, MW-570, MW-571, MW-572, MW-573, MW-574, MW-575, MW-576, MW-577, MW-578, MW-579, MW-580, MW-581, MW-582, MW-583, MW-584, MW-585, MW-586, MW-587, MW-588, MW-589, MW-590, MW-591, MW-592, MW-593, MW-594, MW-595, MW-596, MW-597, MW-598, MW-599, MW-600, MW-601, MW-602, MW-603, MW-604, MW-605, MW-606, MW-607, MW-608, MW-609, MW-610, MW-611, MW-612, MW-613, MW-614, MW-615, MW-616, MW-617, MW-618, MW-619, MW-620, MW-621, MW-622, MW-623, MW-624, MW-625, MW-626, MW-627, MW-628, MW-629, MW-630, MW-631, MW-632, MW-633, MW-634, MW-635, MW-636, MW-637, MW-638, MW-639, MW-640, MW-641, MW-642, MW-643, MW-644, MW-645, MW-646, MW-647, MW-648, MW-649, MW-650, MW-651, MW-652, MW-653, MW-654, MW-655, MW-656, MW-657, MW-658, MW-659, MW-660, MW-661, MW-662, MW-663, MW-664, MW-665, MW-666, MW-667, MW-668, MW-669, MW-670, MW-671, MW-672, MW-673, MW-674, MW-675, MW-676, MW-677, MW-678, MW-679, MW-680, MW-681, MW-682, MW-683, MW-684, MW-685, MW-686, MW-687, MW-688, MW-689, MW-690, MW-691, MW-692, MW-693, MW-694, MW-695, MW-696, MW-697, MW-698, MW-699, MW-700, MW-701, MW-702, MW-703, MW-704, MW-705, MW-706, MW-707, MW-708, MW-709, MW-710, MW



PLUME B



- Plume area = 71 acres
- $TCE_{MAX} = 102.7 \mu\text{g/L}$; $TCE_{MASS} = 48 \text{ kg}$; $cDCE_{MAX} = 123 \mu\text{g/L}$
 - Source RI $TCE_{MAX} = 888 \mu\text{g/L}$
- No evidence of continuing source (residual/adsorbed phase)
- Plume stable, edges shrinking
 - ▽ ↓ TCE over last 10-15 years
 - Biodegradation evident (presence of *cis*-1,2-DCE)
 - Half-life_{AVG} for TCE ~ 7 years
- Plume attenuates in floodplain of Crow Creek
 - Dilution, volatilization
 - Mass loading to Crow Creek ~ 0.6 gm/day
 - Empirical SW data < 1 $\mu\text{g/L}$



PLUME B ALTERNATIVES



Shallow Zone Alternatives:

- ▣ 1B - No Action
- ▣ 2B - Institutional Controls
- ▣ 3B - MNA
- ▣ 4B - P&T & MNA
- ▣ 5B - ChemOx & MNA

Intermediate Zone Options:

- ▣ 1B-INT - No Action
- ▣ 2B-INT - Institutional Controls
- ▣ 3B-INT - MNA
- ▣ 4B-INT - Localized ChemOx & MNA



ALTERNATIVE 3B



MNA

- ▢ MNA :
 - 12 shallow wells + 4 intermediate wells
- ▢ Time to achieve RAOs ($\text{TCE} < 5 \mu\text{g/L}$)
 - Shallow: 65 years
 - Intermediate: 110 years



ALTERNATIVE 4B



P&T & MNA

- ▢ P&T:
 - 23 extraction wells, 30 gpm
- ▢ MNA:
 - 12 shallow wells + 4 intermediate wells
- ▢ Time to achieve RAOs ($\text{TCE} < 5 \mu\text{g/L}$)
 - Shallow: 30 years (10 yrs P&T + 20 yrs MNA)
 - Intermediate: 110 years



ALTERNATIVE 5B



ChemOx & MNA

□ ChemOx (KMnO_4):

- Applied to area above and in intermediate plume
- $> 50 \mu\text{g/L}$
- ~ 4 acres, 139 injection points (20 ft grid)

□ MNA:

- 12 shallow wells + 4 intermediate wells

□ Time to achieve RAOs ($\text{TCE} < 5 \mu\text{g/L}$)

- Shallow: 35 years
- Intermediate: 35 years



PLUME B SUMMARY



| Alternative | Description | Timeframe to Achieve Groundwater RAOs (Years) | Capital Costs | Total O&M Cost | Present Value Cost |
|-------------|---|---|---------------|----------------|---------------------------|
| 1B | No Further Action | 65 | -- | -- | -- |
| 2B | Institutional Controls | 65 | \$18,484 | \$155,155 | \$63,341 |
| 3B | MNA | 65 | \$0 | \$4,461,154 | \$1,619,883 |
| 4B | Groundwater Extraction, <i>Ex situ</i> Treatment, & MNA | 30 | \$1,176,281 | \$6,783,913 | \$5,361,029 |
| 5B | ChemOx & MNA | 35 | \$914,625 | \$3,247,947 | \$2,391,476 |
| 1B-INT | No Further Action | 110 | -- | -- | \$1,200 |
| 2B-INT | Institutional Controls | 110 | \$0 | \$105,028 | \$1,765 (Years 66-110) |
| 3B-INT | MNA | 110 | \$0 | \$3,912,184 | \$700,323 |
| 4B-INT | Localized ChemOx & MNA | 35 | \$1,500,411 | \$1,279,268 | \$2,030,068 |

[illegible]



PLUME C



- ▢ Plume area = 79 acres
- ▢ $TCE_{MAX} = 2,273 \mu\text{g/L}$; $TCE_{MASS} = 191 \text{ kg}$
 - $TCE \sim 6,870 \mu\text{g/L}$ in test well (Source RI)
- ▢ Localized continuing sources (residual/adsorbed phase)
 - locally $TCE \uparrow$
- ▢ Portions of plume stable, edges shrinking
 - ▽ ▢ TCE less than other plumes
 - Biodegradation evident (presence of cis-1,2-DCE)
 - Half-life_{AVG} for $TCE \sim 12$ years
- ▢ Plume intercepts & flows under Crow Creek
 - Mass loading to Crow Creek estimated at 3.7 gm/day
 - Empirical SW data $\sim < 1 \mu\text{g/L}$ but a maximum of 12 at C5.2
- ▢ Sensitive species habitat (CO Butterfly Plant & Preble's Mouse)



PLUME C ALTERNATIVES



Shallow Zone Alternatives:

- ▣ 1C - No Action
- ▣ 2C - Institutional Controls
- ▣ 3C - P&T & MNA
- ▣ 4C - ChemOx (plume head), Localized ChemOx, PRB, & MNA
- ▣ 5C - ERH/SVE (plume head), Localized ChemOx, PRB, & MNA
- ▣ 6C - P&T (plume head), Localized ChemOx, PRB, & MNA

Intermediate Zone Options:

- ▣ 1C-INT - No Action
- ▣ 2C-INT - Institutional Controls
- ▣ 3C-INT - MNA
- ▣ 4C-INT - Localized ChemOx & MNA



ALTERNATIVE 3C



P&T & MNA

▮ P&T:

- 67 extraction wells, 53 gpm

▮ MNA:

- 12 shallow wells + 4 intermediate wells

▮ Time to achieve RAOs ($\text{TCE} < 5 \mu\text{g/L}$)

- Shallow: 30 years (20 yrs P&T + 10 yrs MNA)
- Intermediate: 100 years



ALTERNATIVE 4C



ChemOx (head), Localized ChemOx, PRB, & MNA

- ▢ ChemOx (Fenton's Reagent):
 - Applied to plume head (~ 0.5 acre treatment zone)
 - 46 electrodes, 46 extraction wells
- ▢ ChemOx (KMnO_4):
 - Applied to areas with TCE > 300 $\mu\text{g/L}$ (~ 2 acres)
 - 112 wells, 113 injection points (20 ft grid) for all chem-ox
- ▢ PRB (creek intercept): ~ 800 feet long
- ▢ MNA:
 - 12 shallow wells + 4 intermediate wells
- ▢ Time to achieve RAOs (TCE < 5 $\mu\text{g/L}$)
 - Shallow: 50 years
 - Intermediate: 100 years



ALTERNATIVE 5C



ERH/SVE, ChemOx, PRB, & MNA

ERH/SVE:

- Applied to plume head (~ 0.5 acre treatment zone)
- 46 electrodes, 46 extraction wells

ChemOx (KMnO_4):

- Applied to areas with TCE > 300 $\mu\text{g/L}$
- ~ 2 acres, 89 injection points (20 ft grid)

PRB (creek intercept): ~ 800 feet long

MNA:

- 12 shallow wells + 4 intermediate wells

Time to achieve RAOs (TCE < 5 $\mu\text{g/L}$)

- Shallow: 50 years (5 yrs P&T + 45 yrs MNA)
- Intermediate: 100 years



ALTERNATIVE 6C



P&T, ChemOx, PRB, & MNA

▮ P&T:

- Applied to plume head (~ 0.5 acre treatment zone)
- 6 extraction wells, 13 gpm

▮ ChemOx (KMnO_4):

- Applied to areas with TCE > 300 $\mu\text{g/L}$
- ~ 2 acres, 89 injection points (20 ft grid)

▮ PRB (creek intercept): ~ 800 feet long

▮ MNA:

- 12 shallow wells + 4 intermediate wells

▮ Time to achieve RAOs (TCE < 5 $\mu\text{g/L}$)

- Shallow: 50 years (5 yrs P&T + 45 yrs MNA)
- Intermediate: 100 years



PLUME C SUMMARY



| Alternative | Description | Timeframe to Achieve Surface Water RAOs (Years) ¹ | Timeframe to Achieve Groundwater RAOs (Years) | Capital Costs | Total O&M Costs | Present Value Cost |
|-------------|---|--|---|---------------|-----------------|---------------------------|
| 1C | No Further Action | 55 | unknown | -- | -- | -- |
| 2C | Institutional Controls | 55 | unknown | \$18,484 | \$167,090 | \$63,775 |
| 3C | Groundwater Extraction, <i>Ex situ</i> Treatment, & MNA | <5 | 30 | \$2,082,278 | \$11,069,595 | \$8,168,509 |
| 4C | ChemOx (head), Localized ChemOx, PRB, & MNA | <5 | 50 | \$3,439,306 | \$3,787,487 | \$4,861,129 |
| 5C | ERH/SVE, Localized ChemOx, PRB, & MNA | <5 | 50 | \$5,954,943 | \$3,939,330 | \$7,280,204 |
| 6C | Groundwater Extraction, <i>Ex situ</i> Treatment, Localized ChemOx, & MNA | <5 | 50 | \$3,460,848 | \$5,610,616 | \$6,391,207 |
| 1C-INT | No Further Action | N/A | 100 | -- | -- | \$1,200 |
| 2C-INT | Institutional Controls | N/A | 100 | \$0 | \$69,223 | \$1,132 (Years 71-100) |
| 3C-INT | MNA | N/A | 100 | \$0 | \$3,200,364 | \$840,958 |
| 4C-INT | Localized ChemOx & MNA | N/A | 60 | \$1,771,712 | \$1,522,530 | \$2,307,002 |

A detailed site map showing various monitoring wells (MW-01 through MW-29) and their elevations. The map includes labels for "ZONE D", "PLUME E", "LF-2a", "LF-2b", and "LF-3". A purple arrow points to a specific well labeled "Iron Injection Study". Other features include "SS-02", "UN-01", "UN-02", "UN-03", "UN-04", "UN-05", "UN-06", "UN-07", "UN-08", "UN-09", "UN-10", "UN-11", "UN-12", "UN-13", "UN-14", "UN-15", "UN-16", "UN-17", "UN-18", "UN-19", "UN-20", "UN-21", "UN-22", "UN-23", "UN-24", "UN-25", "UN-26", "UN-27", "UN-28", "UN-29". The map also shows topographic contours, roads, and buildings. A legend at the bottom left identifies symbols for monitoring wells, injection wells, and other features.



PLUME E



- ▮ Plume area = 80 acres
- ▮ $TCE_{MAX} = 449.7 \mu\text{g/L}$; $TCE_{MASS} = 106 \text{ kg}$
 - Benzene $\sim 10.7 \mu\text{g/L}$ at single location near head; no RAO
- ▮ No evidence of continuing source (residual/adsorbed phase)
- ▮ Plume stable, edges shrinking
 - ∇ ↓ TCE over last 10-15 years
 - Biodegradation evident (presence of cis-1,2-DCE)
 - Half-life_{AVG} for TCE ~ 5 years
- ▮ Plume attenuates in floodplain of Crow Creek
 - Dilution, volatilization
 - Mass loading to Crow Creek $\sim 0.3 \text{ gm/day}$
 - Empirical SW data $< 1 \mu\text{g/L}$



PLUME E ALTERNATIVES



Shallow Zone Alternatives:

- ▣ 1E - No Action
- ▣ 2E - Institutional Controls
- ▣ 3E - MNA & Existing PRB
- ▣ 4E - P&T, MNA, & Existing PRB
- ▣ 5E - Localized Bioaugmentation, MNA, & Existing PRB
- ▣ 6E - Localized ChemOx & MNA (discount PRB)

Intermediate Zone Options:

- ▣ 1E-INT - No Action
- ▣ 2E-INT - Institutional Controls
- ▣ 3E-INT - MNA
- ▣ 4E-INT - Localized ChemOx & MNA



ALTERNATIVE 3E



MNA & Existing PRB

- ▢ MNA:
 - 12 shallow wells + 4 intermediate wells
- ▢ PRB from Treatability Study
- ▢ Time to achieve RAOs ($\text{TCE} < 5 \mu\text{g/L}$)
 - Shallow: 70 years
 - Intermediate: 130 years



ALTERNATIVE 4E



P&T, MNA, & Existing PRB

▮ P&T:

- 30 extraction wells, 35 gpm, 10 yrs

▮ MNA:

- 12 shallow wells + 4 intermediate wells

▮ PRB from Treatability Study

▮ Time to achieve RAOs ($\text{TCE} < 5 \mu\text{g/L}$)

- Shallow: 40 years (10 yrs P&T, then 30 years MNA)
- Intermediate: 130 years



ALTERNATIVE 5E



Localized Bioaugmentation, MNA, & Existing PRB

- ▮ Bioaugmentation:
 - 0.83 acres, 1141 injection points
- ▮ MNA:
 - 12 shallow wells + 4 intermediate wells
- ▮ PRB from Treatability Study
- ▮ Time to achieve RAOs ($\text{TCE} < 5 \mu\text{g/L}$)
 - Shallow: 40 years
 - Intermediate: 130 years



ALTERNATIVE 6E



ChemOx & MNA (discount existing PRB)

ChemOx (KMnO_4):

- Applied to area $S > 50 \mu\text{g/L}$
- ~ 4 acres, 1141 injection points (20 ft grid)

MNA:

- 12 wells + 4 wells
- Time to achieve RAOs ($\text{TCE} < 5 \mu\text{g/L}$)
 - Shallow: 40 years
 - Intermediate: 130 years

PLUME E SUMMARY

| Alternative | Description | Timeframe to Achieve Groundwater RAOs (Years) | Capital Costs | Total O&M Cost | Present Value Cost |
|-------------|---|---|---------------|----------------|---------------------------|
| 1E | No Further Action | 70 | -- | -- | -- |
| 2E | Institutional Controls | 70 | \$18,484 | \$167,090 | \$63,775 |
| 3E | MNA & Existing PRB | 70 | \$0 | \$4,711,571 | \$1,627,952 |
| 4E | Groundwater Extraction, <i>Ex situ</i> Treatment, MNA, & Existing PRB | 40 | \$1,351,304 | \$7,138,460 | \$5,583,086 |
| 5E | Bioaugmentation, MNA, Existing PRB | 40 | \$9,022,858 | \$3,743,748 | \$10,141,585 |
| 6E | Localized ChemOx & MNA (discount Existing PRB) | 40 | \$6,476,174 | \$3,497,868 | \$7,714,007 |
| 1E-INT | No Further Action | 130 | -- | -- | \$1,200 |
| 2E-INT | Institutional Controls | 130 | \$0 | \$140,833 | \$1,298 (Years 71-130) |
| 3E-INT | MNA | 130 | \$0 | \$4,623,337 | \$685,885 |
| 4E-INT | Localized ChemOx & MNA | 35 | \$6,653,958 | \$1,279,268 | \$6,938,208 |



SUMMARY OF RECOMMENDED ALTERNATIVES



| PLUME | ALTERNATIVE | DESCRIPTION | COST |
|-------|-------------|---|-------------|
| A | 3A | MNA | \$1,133,542 |
| | 3A-INT | MNA | \$ 794,761 |
| SS7 | 5S | Existing PRB, Bioaug, & MNA | \$4,208,345 |
| | 3S-INT | MNA | \$ 741,263 |
| B | 3B | MNA | \$1,619,883 |
| | 3B-INT | MNA | \$ 700,323 |
| C | 4C | ChemOx (head), Localized ChemOx, PRB, and MNA | \$5,520,831 |
| | 3C-INT | MNA | \$ 840,958 |
| E | 3E | MNA & Existing PRB | \$1,627,192 |
| | 3E-INT | MNA | \$ 685,885 |



DISCUSSION/Q&A SESSION



MEETING LOGISTICS

May 18, 2004
Little America



ADJOURNMENT